THE TARDIGRADA OF SIGNY ISLAND, SOUTH ORKNEY ISLANDS, WITH A NOTE ON THE ROTIFERA

By Peter G. Jennings

Abstract. 16 species of Tardigrada are recorded from 43 habitats on Signy Island. The sites sampled ranged from lichens and mosses to fresh-water habitats. 11 new records have been added to the South Orkney Islands' fauna, and one genus, *Oreella*, to the fauna of the Antarctic. Population densities are reported for each species or species group from eight sites together with estimates of biomass. Total tardigrade densities ranged from $0\cdot011 \pm 0\cdot007 \times 10^6$/m.^{2} in a *Polytrichum–Chorisodontium* moss turf to $14\cdot130 \pm 3\cdot242 \times 10^6$/m.^{2} in a mat of the foliose alga *Prasiola crispa*. Densities were higher in sites affected by vertebrates. Four species accounted for 95·1 per cent of the total tardigrade biomass. These were *Hypsibius* (*Hypsibius*) *dujardini* Doy., *Hypsibius* (*Diphascon*) *pinguis* Marcus, *Hypsibius* (*Diphascon*) *alpinus* J. Murr. and *Macrobiotus furciger* J. Murr.

Few species lists of Tardigrada from Antarctic or sub-Antarctic regions are available (Murray, 1906, 1910; Richters, 1907, 1908; Morikawa, 1962; Sudzuki, 1964; Ramazzotti, 1972*b*). The only specific identifications from the South Orkney Islands are those given by Murray (1906), who described poorly preserved specimens from Laurie Island, only 30 miles (50 km.) east of Signy Island.

Between January 1971 and April 1973 the temporal and spatial distribution of the Tardigrada and Rotifera at two selected sites on Signy Island, South Orkney Islands, were investigated. While this work was in progress a general survey was made of the species composition and, wherever possible, the population density of the two groups in a variety of other habitats on the island. The results of the survey are presented here.

Methods

Quantitative examination

Extraction. Where possible, population-density estimates of Tardigrada and Rotifera were made from cores (3·5 cm. diameter and 3·0 cm. depth) but where coring was impracticable all vegetation down to bedrock within a quadrat 5 cm. square was collected. Except at two sites, 20 sample units were taken on each occasion.

Three methods of extraction were considered:

i. Wet funnel (Baermann, 1917).
ii. Seinhorst mistifier (Seinhorst, 1950).
iii. Modified Baermann or "tray method" (Whitehead and Hemming, 1965).

The most efficient process for this study was found, by experiment, to be the modified Baermann method. This method was originally employed for the extraction of active Nematoda and has been fully described by Whitehead and Hemming (1965). It also appears to work successfully for the Tardigrada and Rotifera, and has been used in a slightly modified form for a quantitative study of the Tardigrada in forest soils by Hallas and Yeates (1972). 22 cm. by 36 cm. plastic seed trays were used and each contained a flat nylon mesh sheet ("Netlon"—[illegible] mm. mesh) supporting a double-ply tissue ("Kleenex Mansize"). The substrate sample unit was teased out on to the tissue and distilled water (approximately 250 ml.) was added until it just covered the mesh. Extraction took place at room temperature which ranged from approximately 10° to 15° C.

In order to determine a suitable extraction period, six cores were left for 4 days and counts made of the Tardigrada and Rotifera extracted at 12 hourly intervals. The number of animals extracted after 96 hr. does not represent the total population at the onset of the experiment and it is necessary to derive a figure for the total population in order to assess extraction efficiency. One estimate of the initial population is based on maximum likelihood (Moran, 1951) and involves the following assumptions concerning the population:

i. That the probability of any animal being extracted remains constant throughout the experiment.
ii. That the population is static (i.e. with no mortality or natality).
iii. That the chance of extraction must be equal for each individual.

An alternative approach is the empirical method of Skellam (1962), where the data are transformed graphically so that estimates of initial population can be read directly from the intercept. These two approaches have been used to estimate the total population for each faunal component in this study (Table I) and there is close agreement between them. Using both

TABLE I. COMPARISON OF THE TOTAL EXTRACTABLE POPULATIONS OF TARDIGRADA AND ROTIFERA PREDICTED BY THE MAXIMUM LIKELIHOOD ESTIMATE (MLE) OF MORAN (1951) AND THE EMPIRICAL METHOD OF SKELLAM (1962). PERCENTAGE EXTRACTION AFTER 24, 48 AND 96 hr. HAS BEEN CALCULATED FOR EACH OF THESE METHODS

	Total numbers			*Per cent extracted from predicted population*					
	Observed	*Predicted*		*Maximum likelihood estimate*			*Skellam's method*		
	After 96 hr.	MLE	Skellam	After 24 hr.	48 hr.	96 hr.	24 hr.	48 hr.	96 hr.
Hypsibius sp.	2,011	2,216	2,780	47	69	91	37	55	72
Macrobiotus sp.	316	356	398	39	70	89	35	63	79
Echiniscus sp.	21	24	22	38	67	88	41	73	95
Bdelloidea	5,093	5,280	6,803	59	78	96	46	61	75
Adineta	1,304	14,243	3,163	2	5	9	10	21	41

estimates, the percentages extracted after 12, 48 and 96 hr. have been calculated (Table I). Although a higher number was recorded after 96 hr., more water had to be added after about 2 days to replace evaporative losses and this inevitably washed detritus into the extractant. It was decided, therefore, to use an extraction period of 48 hr. for all subsequent work.

Hallas and Yeates (1972) tested their extraction efficiency by introducing a known number of Tardigrada into autoclaved soil. They recovered 87 per cent in 24 hr. This is a much higher figure than was found in the present study, although their result is not directly comparable, since they were using a different substrate which had been homogenized prior to extraction.

It was considered that the three assumptions required by the maximum likelihood estimate held true for the Tardigrada. All tardigrade densities reported in this paper have therefore been increased by 30 per cent, since this method predicts about 70 per cent extraction in 48 hr. for the three genera of Tardigrada. However, the densities reported for the Rotifera have not been increased as there is some evidence that the population changed during the extraction. Isolated Rotifera were kept in a hanging drop under the conditions of an extraction and were observed daily for a period of 21 days. Nine of the ten Rotifera studied produced eggs within the first 6 days, and three within the first 4 days. Of those which produced eggs, the mean duration between successive eggs was 3 days, and each egg took between 6 and 7 days to hatch. The favourable environment during extraction may therefore hasten the development of eggs already in the moss core.

The very low efficiency predicted by both methods for *Adineta* may be accounted for by consideration of its feeding habits. *Adineta* does not possess the trochal discs of other bdelloid Rotifera, and the rostrum is not retractile. Instead it glides over the substrate on its ciliated rostral area cropping the overlying film. It is thus possible that this dependence on contact with the substrate makes it less likely for the animals to move down into the extraction tray.

It was noted during counting that at water temperatures above 15° C the tardigrades became less active and often formed "tuns" (reducing their surface area by assuming a short barrel shape), although during the summer months, this temperature was often exceeded in the mosses of Signy Island. However, ambient temperatures during extractions were not allowed to exceed this figure. After extraction the water in each tray was rinsed into stoppered bottles and stored at 7° C.

Identification and counting. It was possible to identify most of the tardigrade species encountered on Signy Island during counting. A check was carried out for each site to determine the species composition by permanently mounting a representative sample for high-power examination ($\times$300, $\times$600 or $\times$1,500). Two species groups have not been resolved in this study (*Echiniscus* (*Echiniscus*) *capillatus* Richters/*E. meridionalis* J. Murr. and *Hypsibius* (*Diphascon*) *pinguis* Marcus/*H. alpinus* (J. Murr.)), because of the difficulty in separation at low powers. The two mountants, polyvinyl lactophenol with 1 per cent cotton blue and Hoyers medium, were used during the study and the latter proved to be the most successful.

The difficulties encountered in studying bdelloid Rotifera have been well documented (Donner, 1951, 1956) and it is this order which comprises most of the moss rotiferan fauna. Generic characteristics often depend on details of the foot and specific identification is only possible when the animals are actively feeding. The Rotifera were therefore placed in the following categories: i. *Adineta*; ii. Bdelloidea (other than *Adineta*); iii. Monogononta; iv. Unidentified—inactive Rotifera.

Counting was started immediately after extraction but it took an average of 2 weeks to complete. There was no evidence that the tardigrade composition changed appreciably during this period. Counts were made at low magnifications on a compound microscope ($\times$45 or, for difficult specimens, $\times$150). Aliquots of 5 ml. from each sample unit were pipetted into a counting cell made from a plastic disposable petri dish (a modification of the Sedgwick-Rafter cell, as used by Pennak (1940) and Arora (1966)).

Population estimates for three sites were obtained by counting five successive 5 ml. aliquots from a bulked sample of five extracted sample units. The estimate of sampling variance obtained in this way is comparable with that obtained by counting each unit individually, but the mean is calculated from only four independent estimates and much information on the spatial dispersion of the population is lost. For all other sites, therefore, either a single 5 ml. aliquot or the entire sampling unit was counted.

The counting procedure relies on a number of assumptions which may or may not hold true for each of the components under study.

i. That the animals in each sample unit immediately prior to sub-sampling conform to a Poisson distribution. This may be tested by taking successive sub-samples from each unit, calculating the variance to mean ratio, and applying a χ^2 test. Results were well within the 5 per cent confidence limits for each faunal component in this study.

ii. That the organisms are immobile in the counting tray. This holds true for the Tardigrada, when separated from their normal substrate. However, the Rotifera remain highly mobile. The Bdelloidea, for example, although rarely swimming freely, were still capable of moving rapidly into and out of the microscope field of view. Consequently, the Rotifera numbers reported are only approximate densities within each site.

iii. That all the animals extracted have been recorded, regardless of size, shape or colour. Although an attempt was made to reduce detritus in the extracted samples to a minimum, a few were so contaminated that some smaller individuals may have been overlooked. Animals in the genus *Echiniscus* posed their own problems in that their coloration, shape and sluggish movements always made them difficult to distinguish from microscopic particles of plant material.

Biomass estimation

Biomass has been estimated by the method used by Hallas and Yeates (1972). All Tardigrada are taken to have a density of 1·04 and except for *Echiniscus*, are assumed to be cylindrical. A weight for each specimen is then given by:

$$\text{Weight} = \text{length} \times \pi \times \left(\frac{\text{length}}{2 \times R}\right)^2 \times 1{\cdot}04 \times 10^{-6}\ \mu\text{g., where } R \text{ is the ratio of length to width.}$$

The shape of *Echiniscus* is assumed to be half a prolate spheroid. The weight is then given by:

$$\text{Weight} = \frac{1}{12} \times \text{length} \times \pi \times \left(\frac{\text{length}}{R}\right)^2 \times 1{\cdot}04 \times 10^{-6}\ \mu\text{g.}$$

The ratios measured and mean weight calculated for each species are given in Table II.

TABLE II. RATIO OF LENGTH : WIDTH AND MEAN ANIMAL WEIGHTS USED IN THE ESTIMATION OF BIOMASS

Species	*Length: width ratio*	*Mean weight* (μg.)
Oreella mollis	3·7	0·034
Echiniscus (*E.*) *capillatus* + *E. meridionalis*	1·9	0·727
Macrobiotus furciger	4·3	4·301
Hypsibius (*H.*) *dujardini*	3·0	1·400
Hypsibius (*I.*) *asper*	2·4	5·750
Hypsibius (*D.*) *alpinus* + *H. pinguis*	2·5	1·076
Hypsibius (*D.*) *chilenensis*	3·3	0·721
Hypsibius (*D.*) *puniceus*	2·5	1·193
Hypsibius (*D.*) *scoticus*	3·6	2·515
Milnesium tardigradum	3·4	26·604

Qualitative examination

Many sites were investigated where coring techniques were not applicable, or where too few cores were taken to permit statistical analysis, and thus no population estimates are available. Here the samples were either extracted and counted in the normal way, or were washed from the moss into a counting tray. The extracted animals were later removed with a fine capillary under a dissecting microscope ($\times 12$) for permanent mounting as described above. The relative abundance of each faunal component was estimated wherever possible.

Measurement of environmental factors

A number of environmental parameters were measured on 19 of the samples:

i. pH—using a portable meter.
ii. Wet weight—to the nearest mg. measured as soon after sampling as possible.
iii. Dry weight—after drying to constant weight at 105° C.
iv. Loss on ignition—from a sub-sample ashed to constant weight at 550° C.
v. Moisture—(a) index of humidity, given by $\text{I.H.} = \dfrac{\text{water content}}{\text{dry weight}}$.
(b) per cent volume, where the initial sample volume was known, given by $\dfrac{\text{water content}}{\text{sample volume}} \times 100$.

SITES

Samples were collected at 43 sites on Signy Island. Eight of these (samples A-H) were subject to a more intensive faunistic analysis and are described below. Details of the remainder (Nos. 1–35) are given in Table III and physical characteristics, where available, are summarized in Table IV.

The most thorough and recent description of Signy Island's vegetation is that of Smith (1972) and his phytosociological classification is used to categorize the sites in the present work.

Sites are located on the Signy Island grid (D.O.S. 210). Origin of grid: lat. 60°40′S., long. 45°40′W.; false coordinates of origin 50,000 N., 100,000 E.

Table III. Description of sites, with sampling dates, used for qualitative examination
(References are given using the grid of Signy Island as shown on D.O.S. 210 Signy Island, 2nd edition. This grid is based on false coordinates of origin 100,000 E., 50,000 N. at lat. 60°40′S., long. 45°40′W.)

Number	*Site*	*Date*	*Site location*	*Notes*
1	*Andreaea* sp. and *Usnea* sp.	Apr. 1971	104^4 044^8 Observation Bluff	Exposed southerly slope on scree
2	*Andreaea* sp. and *Usnea* sp., and unidentified lichens	Oct. 1972	100^8 046^3 Thulla Point	Isolated on large rock on slight easterly slope
3	Unidentified crustose lichens	Aug. 1972	104^4 042^6 Islets off Gourlay Peninsula	On overhanging rocks
4	*Caloplaca regalis*	Sep. 1971	104^3 042^7 Gourlay Peninsula	Southerly cliff face, on ledges
5	*Polytrichum alpestre*	May 1971	103^9 045^2 Factory Cove	Small area affected by elephant seals
6	*Chorisodontium aciphyllum*	Oct. 1972	101^0 046^8 Foca Point	Eroded moribund clump near giant petrel nests
7	*Brachythecium austro-salebrosum*	Oct. 1972	103^9 045^1 Factory Bluffs	On ledges, affected by cape pigeons
8	*Calliergidium austro-stramineum*	Feb. 1973	103^2 044^8 Moraine Valley	Bordering melt stream
9	*Drepanocladus uncinatus* and *Brachythecium* sp.	Mar. 1964	102^2 048^4 North-west coast	Slight north-westerly slope (collected by P. J. Tilbrook)
10	*Drepanocladus uncinatus*	Mar. 1971	101^1 046^9 Foca Cove	Extensive stand
11	*Drepanocladus uncinatus*	Feb. 1973	103^0 045^7 Marble Knolls	Extensive discoloured stand
12	*Prasiola crispa*	Apr. 1971	104^0 045^2 Factory Cove	In dry melt-stream channel
13	*Prasiola* and unidentified lichens	Sep. 1971	104^6 042^9 Gourlay Peninsula	On cliffs
14	*Prasiola crispa*	Feb. 1972	103^8 044^4 Paal Harbour	Around pools (Goodman, 1969)
15	*Prasiola crispa*	Feb. 1972	104^0 045^2 Factory Cove	On scree
16	*Prasiola crispa* and *Drepanocladus uncinatus*	Oct. 1972	102^4 049^1 North Point	On rock in penguin rookery
17	*Prasiola* and unidentified lichens	Oct. 1972	102^4 049^1 North Point	As in 16
18	*Prasiola crispa*	Oct. 1972	104^5 042^9 Gourlay Peninsula	Outside field hut
19	*Prasiola crispa*	Oct. 1972	099^9 044^8 Jebsen Point	Underside of overhanging cliff
20	*Prasiola crispa*	Jan. 1973	103^5 045^5 Cemetery Flats	Over moulted elephant-seal hair
21	*Deschampsia antarctica*	Apr. 1971	104^4 045^0 Observation Bluff	
22	Organic material	Feb. 1972	102^3 049^2 North Point	From area around penguin rookery
23	Organic material	Apr. 1971	103^9 045^2 Factory Cove	Disused dam built by whalers, now flooding in summer and heavily drifted in winter
24	Organic material	Feb. 1973	103^5 045^6 Cemetery Flats	Disused wallow
25	Pool	Mar. 1973	103^7 043^2 SIRS 2	Permanent standing water
26–28	Pools	Feb. 1972	103^8 044^4 Paal Harbour	Fully described by Goodman (1969)
29–35	Lakes			Fully described by Heywood (1967, 1968)

TABLE IV. PHYSICAL PARAMETERS OF THE TERRESTRIAL SITES, INCLUDING pH, WET WEIGHT, DRY WEIGHT, LOSS ON IGNITION AND WATER CONTENT

Number	*Site*	*Date*	*pH*	*Wet weight* (g.)	*Dry weight* (g.) *at 105° C*	*Loss on ignition per cent dry weight at 550° C*	*Index of humidity*	*Moisture, per cent by volume*
A	*Andreaea/Usnea*	Mar. 1973	4·5	17·86	5·75	53·23	2·61	—
2	*Andreaea/Usnea*	Oct. 1972	4·5	28·02	6·45	—	3·34	—
B	*Caloplaca*	Mar. 1973	—	8·93	3·10	—	2·32	—
C	SIRS 1	Mar. 1973	—	17·13	3·34	96·64	4·22	47·79
6	*Chorisodontium*	Oct. 1972	3·6	24·42	4·00	94·49	5·11	—
7	*Brachythecium*	Oct. 1972	4·5	9·88	2·74	—	2·60	—
8	*Calliergidium*	Feb. 1973	6·0	21·39	1·33	69·91	15·04	69·49
H	*Drepanocladus*	Mar. 1973	—	21·51	3·06	—	6·80	63·91
11	*Drepanocladus*	Feb. 1973	6·1	11·80	1·62	87·88	6·26	35·25
16	*Drepanocladus*	Oct. 1973	4·4	28·83	3·99	79·34	6·23	—
D	SIRS 2	Mar. 1973	5·0	23·57	1·24	93·46	19·67	77·37
E	*Prasiola*	Mar. 1973	5·1	21·77	4·55	89·16	5·04	59·65
17	*Prasiola*/lichen	Oct. 1972	—	6·05	4·40	66·01	0·37	—
18	*Prasiola*	Oct. 1972	4·4	4·07	1·06	—	2·84	—
19	*Prasiola*	Oct. 1972	—	1·05	0·66	94·70	1·27	—
20	*Prasiola*	Jan. 1973	7·3	8·96	6·74	57·51	0·57	7·68
F	*Deschampsia*	Mar. 1973	4·4	27·44	9·58	46·33	2·49	61·88
G	Organic material	Mar. 1973	6·6	28·98	12·20	41·40	1·76	58·14
24	Organic material	Feb. 1973	7·3	29·56	18·23	24·82	0·62	39·26

Andreaea–Usnea association of the fruticose lichen and moss-cushion sub-formation. Location 101^3 047^0.

This is the commonest and most widespread association on Signy Island and probably throughout the maritime Antarctic. The site was located on a north-facing slope, overlooking Express Cove on the west coast of the island, at an altitude of about 20 m. It consisted of a fairly extensive mixed community of *Andreaea* sp. and *Usnea* sp. overlying a mineral soil, but approximately 25 per cent of the site was vegetation-free owing to the disruptive effects of frost heaving. The moss had a maximum depth of 3 cm., although the fruticose lichen reached a height of 3–4 cm. above the general vegetation level. In spring and summer the sub-soil was locally water-logged from melt water originating in snow patches higher up the slope. Two samples of 20 units were taken from this site by the quadrat method, one in late winter (October 1972) the other in late summer (March 1973).

Caloplaca–Xanthoria association of the crustose lichen sub-formation. Location 103^9 045^1.

This lichen community is common on nitrogen-enriched rock faces and in large rock crevices, particularly near bird colonies. The site chosen was on Factory Bluffs. Drainage water flushed over the lichens carrying with it organic nutrient from the nests of cape pigeons (*Daption capensis* Linn.) at a higher altitude on the cliffs. Owing to the difficulty of sampling this habitat, only five quadrat sample units were taken in March 1973.

Polytrichum alpestre–Chorisodontium aciphyllum association of the moss-turf sub-formation. Location 103^8 043^3.

Banks of this association constitute one of the most prominent features of vegetation on the island, and the site chosen was one being used for a long-term study of this moss community—Signy Island reference site (SIRS) 1 (Tilbrook, 1973). 19 cores were taken from this site in March 1973.

Calliergidium–Calliergon–Drepanocladus association of the moss-carpet sub-formation. Location 103^5 043^1.

Many permanently moist or wet habitats at low altitudes are vegetated with this mixed moss community. The site chosen, SIRS 2 (Tilbrook, 1973), is dominated by *Calliergon sarmentosum* (Wahlenb.) Kindb., *Drepanocladus uncinatus* (Hedw.) Warnst. and the leafy liverwort *Cephaloziella* sp. Two samples of 20 cores were taken, one in October 1972 and the other in March 1973.

Prasiola crispa association of the alga sub-formation. Location 103^5 045^5.

The site was situated in a shallow depression behind a beach to the south of Drying Point and consisted of a dense mat of the green foliose alga *P. crispa* Meneghini overlying moribund moss and associated peat. This alga is usually associated with areas contaminated by excreta from bird or seal concentrations and in this instance an elephant-seal wallow was situated nearby. The peat thickness was small with bedrock lying 3–4 cm. below the algal layer and, locally, pools formed on the surface. 20 cores were taken from this site in March 1973.

Deschampsia antarctica association of the grass and cushion chamaephyte sub-formation. Location 103^9 045^1.

Locally abundant patches of the grass *D. antarctica* Desv. are restricted to certain areas of the island and generally occur on north-facing slopes (Edwards, 1972). The site was a north-west-facing ledge on Factory Bluffs. Grass covered an area of approximately 1 m.^{2} to a depth of about 3 cm. Two samples of 20 cores were taken from this site, one in late winter (October 1972) and the other in late summer (March 1973).

Seal-wallow material. Location 103^5 045^5.

In an attempt to assess the effect on the tardigrade fauna of high concentrations of nitrogen and phosphorus waste from seals (Allen and others, 1967), an area of fine water-borne mud on the beach just to the south of Drying Point was chosen. The site was intermittently flooded and received large amounts of run-off from a nearby elephant-seal wallow. Also present on the site was a large number of decomposing oak barrel staves discarded by whalers who worked on the island before 1930 (Marr, 1935). A sample of 20 cores was taken from this site in March 1973.

Moss affected by penguins. Location 104⁵ 042⁷.

Stands of various species of mosses were present above the rookery area on Gourlay Peninsula. An extensive area of pure *D. uncinatus* was chosen, on which, at the time of coring, several chinstrap penguins (*Pygoscelis antarctica* (Forster)) were found. The whole area was heavily marked with droppings and covered with a layer of moulted feathers, although no evidence was found of the disruptive effects of trampling. The site was on a slight slope with an easterly aspect and at approximately 20 m. altitude. A sample of 20 cores was taken from this site in March 1973.

Annotated List of Tardigrada

The salient features of each of the 16 species are briefly described and habitat notes for each species are given. The scheme of systematics used throughout this paper is that suggested by Ramazzotti (1962, 1972*a*) and the species have been identified using the keys of the latter publication. The distribution given for each species is that reported by Ramazzotti (1972*a*).

Order Heterotardigrada Marcus 1927

Sub-order Echiniscoidea Marcus 1927

Family Oreellidae Puglia 1959

Oreella mollis J. Murr. 1910
Fig. 1

Length 84 μm. Eyes absent. Cuticle dorsally and laterally covered by rounded papillae which become fine granules anteriorly. Very fine granulation ventrally. Buccal aperture sub-terminal. Internal buccal cirri fine, 3 μm. long. Cephalic papillae fleshy and conical. External cephalic cirri fine, 6 μm. long. Lateral cirrus A long (35 μm.) and filiform. Clava shorter (10 μm.) but thicker (1 μm.), arising from a common bulbous base as the cirrus. Bifid conical protuberance on the medial line at the caudal extremity. Legs long (15 μm. at the IV pair). Four large claws without spurs.

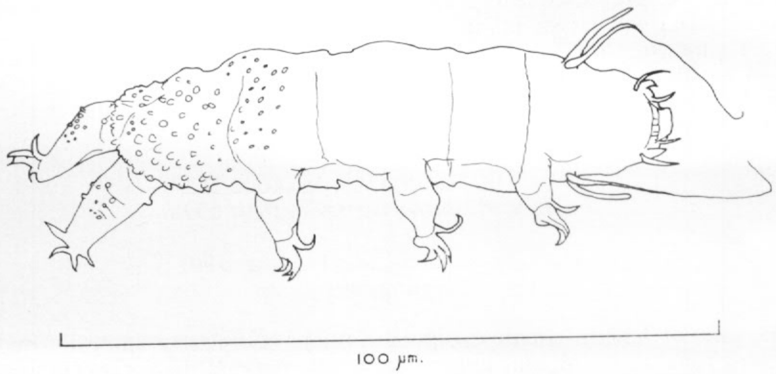


Fig. 1. *Oreella mollis* J. Murr. General body plan.

Found, in small numbers only, at sites A and 12 on Signy Island. This species has previously been recorded only from Australia and, dubiously, Switzerland.

FAMILY ECHINISCIDAE THULIN 1928

Echiniscus (*Echiniscus*) *meridionalis* J. Murr. 1906
Fig. 2

Length 109–163 μm. Sculpture fine depressions. For 109 μm. specimen, cirrus A 43 μm. long, with papilla at its base. Medial plate 3 present. Terminal plate with notches. Filament C 35 μm. Filament C^d 45 μm. Short spine D 4 μm., and a trace of spine D^d. Filament E long (87 μm.). Indented collar on the IV pair of legs. Internal claws 8 μm., with a spur curved toward the base.

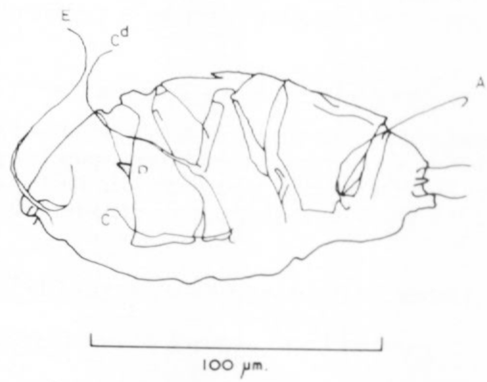


Fig. 2. *Echiniscus* (*E.*) *meridionalis* J. Murr. Position of appendages.

This species was originally described from the South Orkney Islands and has been reported only from the Antarctic.

Echiniscus (*Echiniscus*) *capillatus* Ramazzotti 1956
Fig. 3

Length 172–244 μm. Robust with reddish coloration. Cirrus A very long, with a mean length 90 per cent of the body length. Sculpture is a diffused granulation all over the dorsal surface (Fig. 3b). Indented collar on the IV pair of legs consisting of 5–8 teeth, their size and distribution irregular. Claw length 18–23 μm., with a sharp backward-pointing spur on the interior pair.

This species has been reported only from Italy, where it was found at an altitude of 2,400 m. The original material was larger in size (300–325 μm.) than the material from Signy Island and had larger claws, reported as 31 μm. The toothed collar is also reported as having 9–10 teeth, some of which may have been missed on the Signy Island material.

Members of the genus *Echiniscus* were found in small numbers at sites A, B, D, F, 11, 15 and 24. They were absent from all lakes and pools.

ORDER EUTARDIGRADA MARCUS 1927
FAMILY MACROBIOTIDAE THULIN 1928

Macrobiotus ambiguus J. Murr. 1907
Fig. 4

Up to 751 μm. in length. Small eyespots. Cuticle completely smooth. Buccal aperture terminal. Buccal tube up to 76 μm. long, with 8 μm. internal diameter. Oval bulb with two macroplacoids, the first 27 μm. long and partially divided, the second 14 μm. long. Micro-

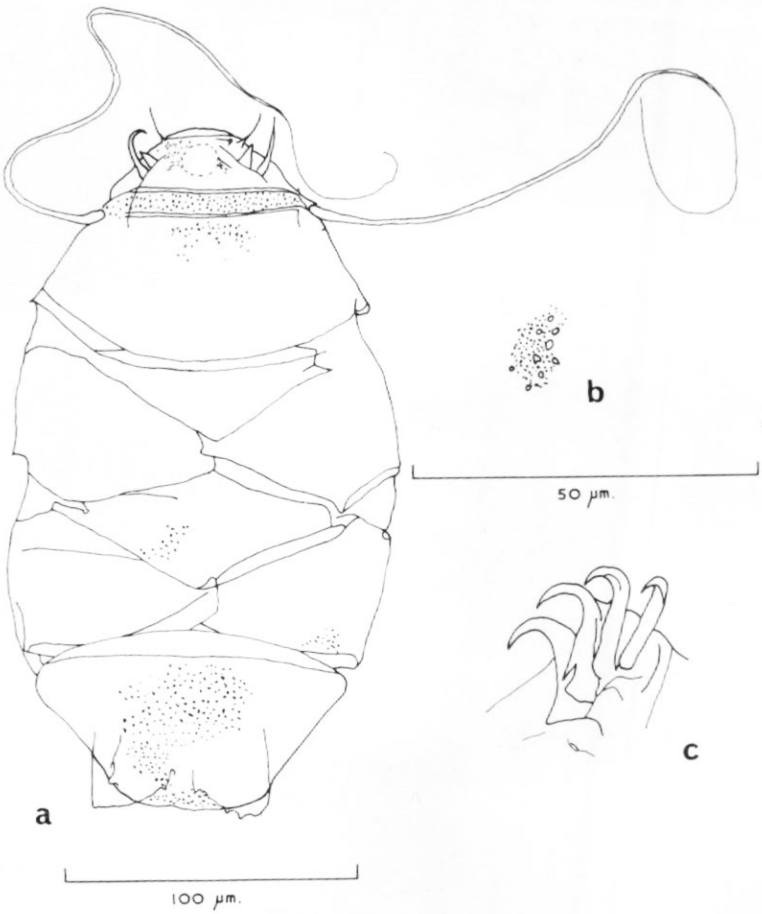


Fig. 3. *Echiniscus (E.) capillatus* Ramazzotti. a. General body plan; b. Detail of sculpture; c. Detail of posterior claw.

placoid absent. Claws large, primary branch of IV pair 34 μm. long and joined to the secondary branch (18 μm. long) at the base. Cuticular fold bridges the claws.

A cosmopolitan species that was recovered from aquatic habitats only on Signy Island (32, 33 and 35).

Macrobiotus furciger J. Murr. 1907
Fig. 5

Length 174–696 μm., typically 450 μm. Cuticle smooth. Eyespots large and set forward. Animal brown in transmitted light. Buccal aperture terminal. A crown of triangular teeth evident in caudal portion of buccal cavity, a feature of the "*Macrobiotus areolatus* type" (Pilato, 1972). Bulb oval (45 μm. by 35 μm.) with three granular macroplacoids (7, 6 and 6 μm.); tear-shaped microplacoids. Claws small (12 μm.). Primary and secondary branches of equal length and fused to half their length. This description of the adult agrees with that of Murray (1906), who recorded this species as the most numerous found in his samples. However, the eggs of this species were laid free, and it has not been possible in this study to relate egg to adult categorically. All the free *Macrobiotus* eggs found in the terrestrial sites had conical ornamentation with bifid processes (Fig. 5c). These are not the same as the eggs of *M. furciger*

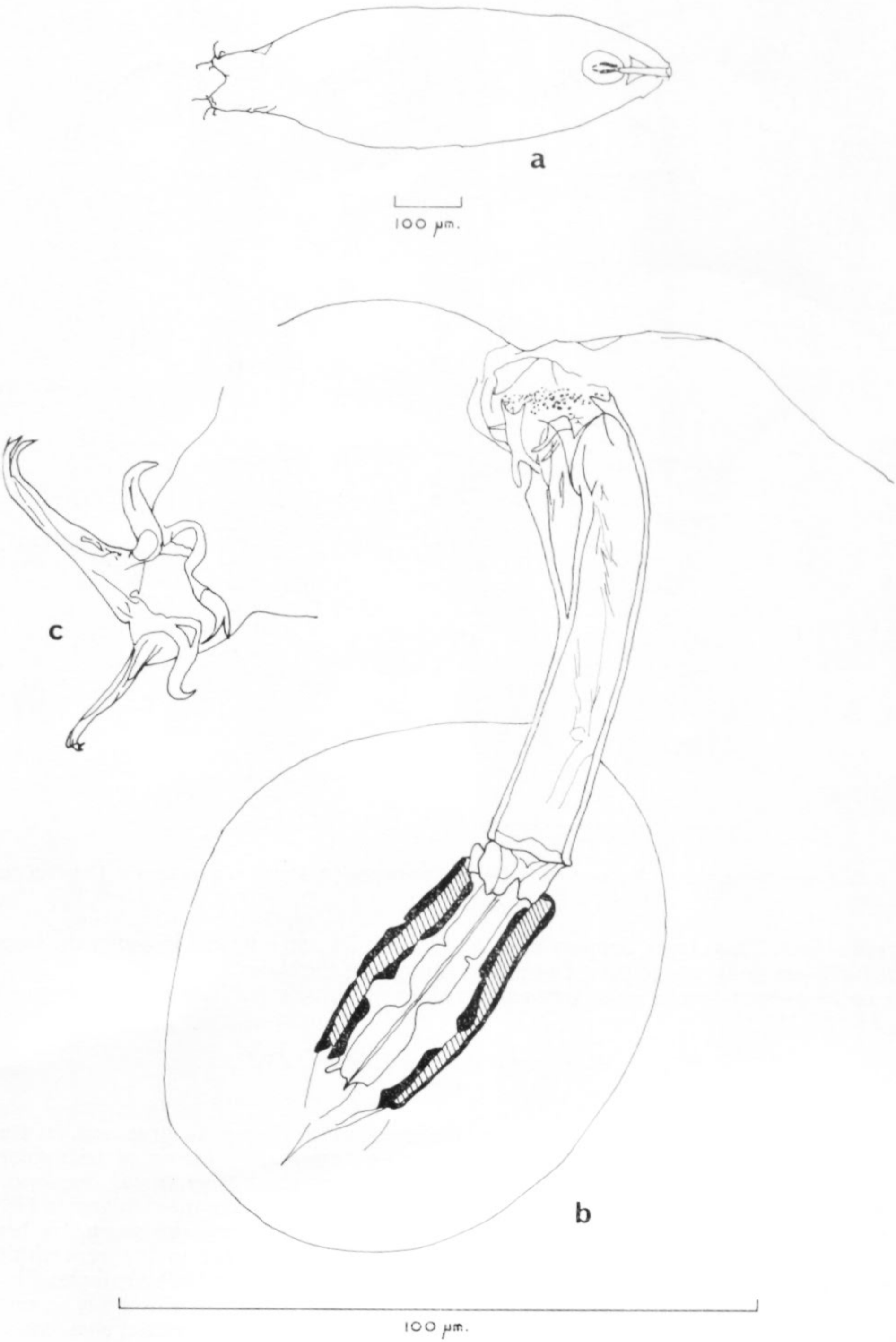
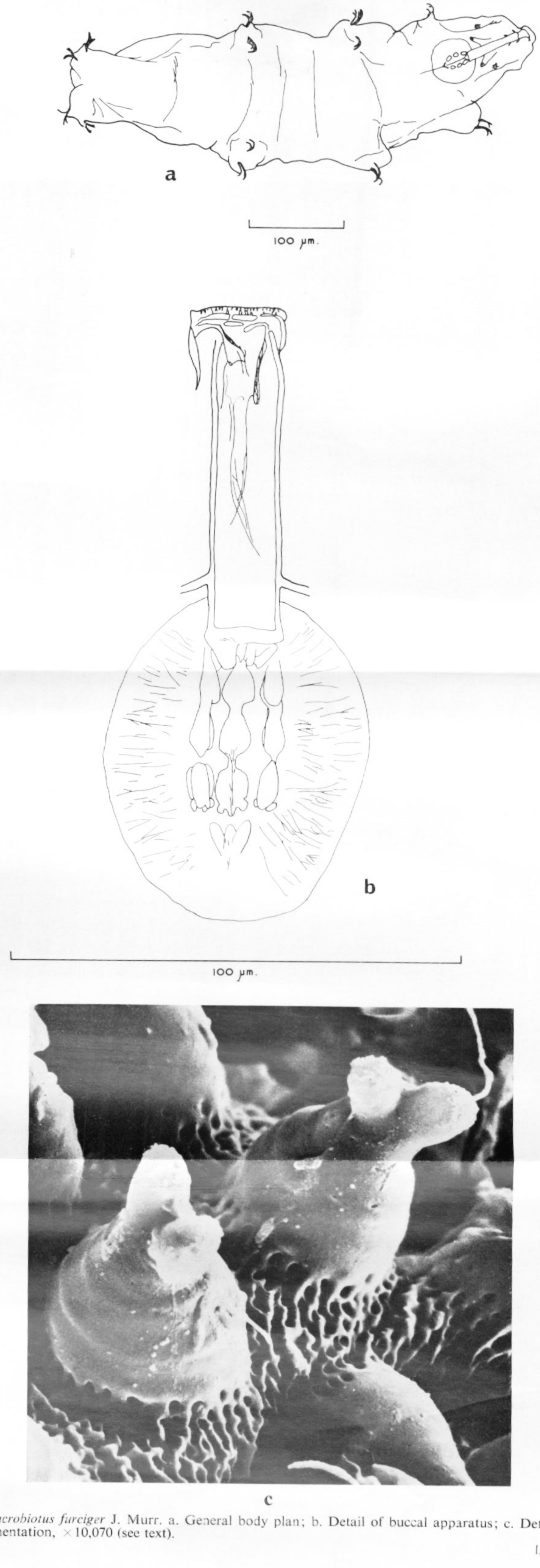


Fig. 4. *Macrobiotus ambiguus* J. Murr. a. General body plan; b. Detail of buccal apparatus; c. Detail of claw.



c

Fig. 5. *Macrobiotus furciger* J. Murr. a. General body plan; b. Detail of buccal apparatus; c. Detail of egg ornamentation, ×10,070 (see text).

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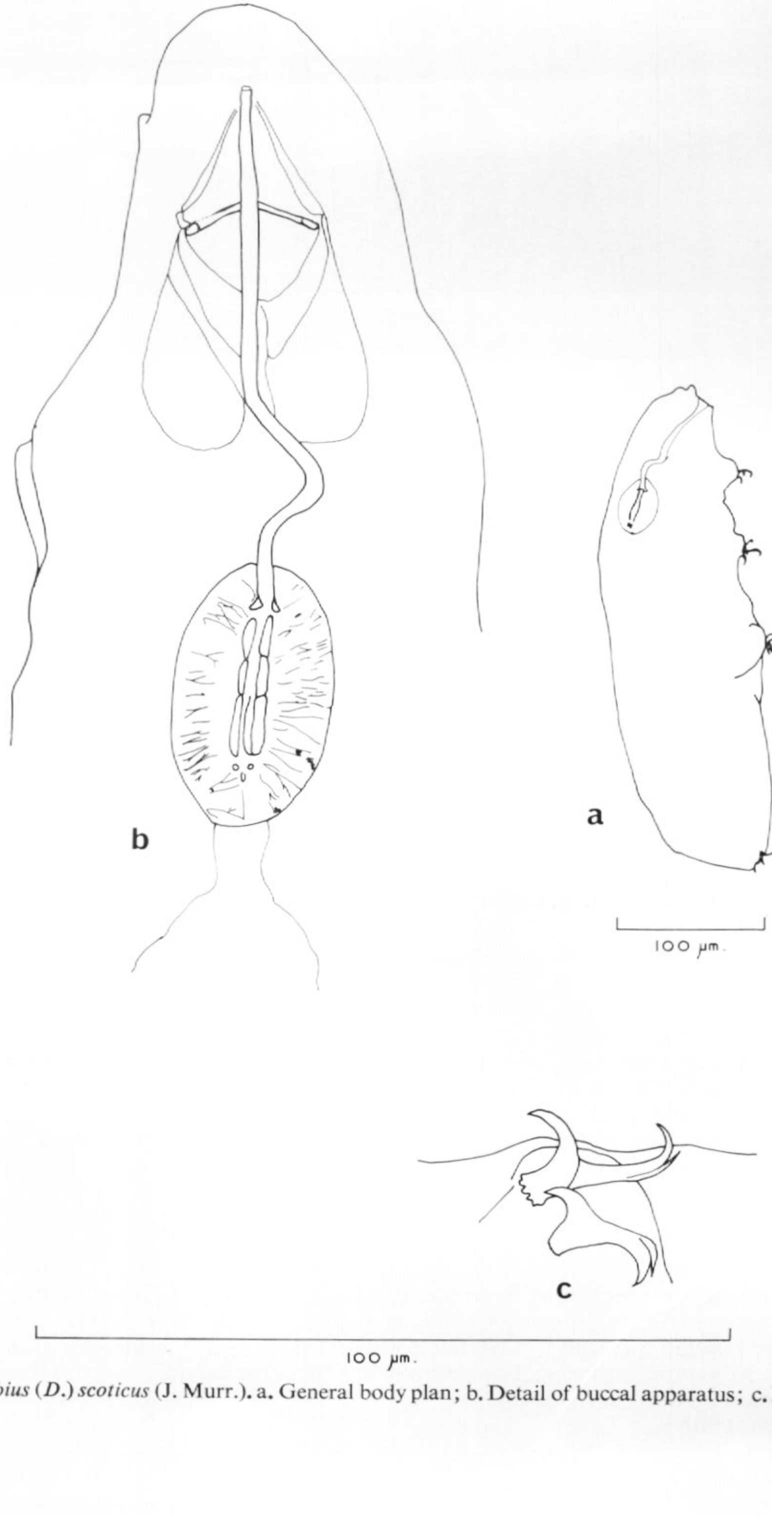

Fig. 12. *Hypsibius* (*D.*) *scoticus* (J. Murr.). a. General body plan; b. Detail of buccal apparatus; c. Detail of claw.

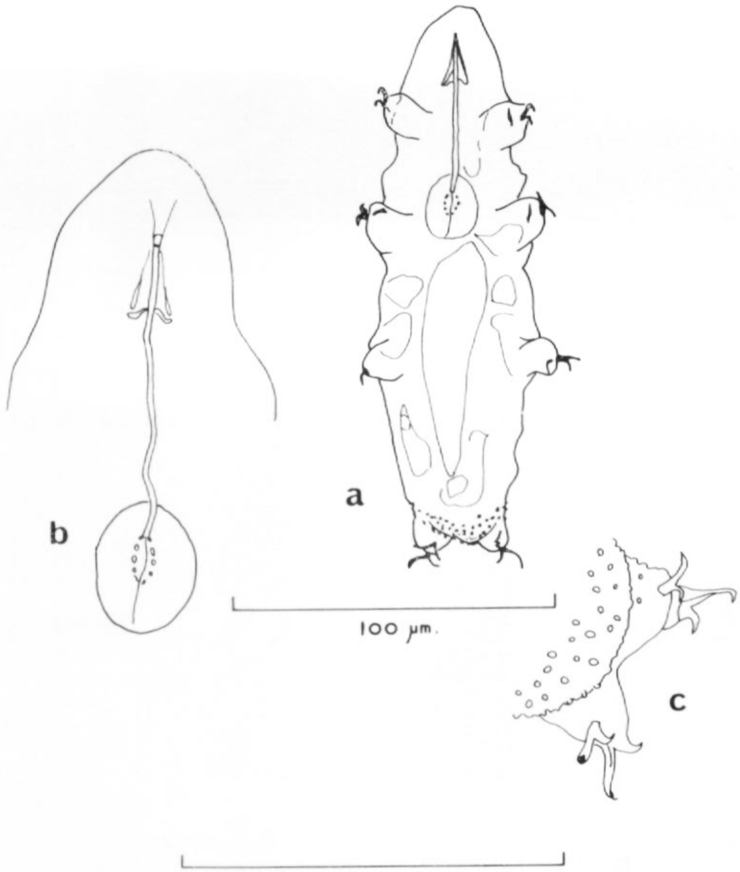

Fig. 11. ***Hypsibius (D.) puniceus*** n. sp. a. General body plan; b. Detail of buccal apparatus; c. Detail of claws.

Hypsibius (Diphascon) scoticus (J. Murr. 1905)
Fig. 12

Length 138–488 µm., typically 322 µm. Cuticle smooth. Eyespots absent. Buccal aperture sub-terminal. Buccal tube 1·5–3·0 µm. diameter, with very clear ring markings. Bulb an elongated oval, up to 50 µm. by 26 µm. Three macroplacoids, 9, 7 and 12 µm. Placoid line 60 per cent of the bulb length. Microplacoids and septulum present.

This species was recovered from sites A, D, E, F, G, H, 8, 12, 15, 16, 23 and 30. The species is cosmopolitan.

Hypsibius (Diphascon) sp.
Fig. 13

Three specimens were recovered from a collection made by P. J. Tilbrook in 1964 at Signy Island. A complete description cannot be given as details of the bulb and its contents are not clear. The most notable feature about the animal is the extensive diffused granulation over both dorsal and ventral surfaces. The animals are black in colour, but this may have been caused by the preservative.

Found only at site 9.

as described by Murray, which have multi-branched processes, but they do correspond with one of his *Macrobiotus* sp. While identification depends on relating adults with particular egg types, confusion in this group is inevitable. Diameter of the egg 96 μm. and 110 μm. with ornamentation.

This species was frequently observed attacking Nematoda and inactive bdelloid rotifers in culture. However, its gut contents were almost invariably green in colour which indicates that the feeding habits of this species are not exclusively carnivorous.

Widely distributed on Signy Island, occurring in sites A, C, D, E, G, H, 1, 2, 5, 6, 7, 10, 11, 15, 16, 17, 18, 20, 23 and 34. Originally described from the South Orkney Islands, the species is cosmopolitan. It has been used for a study on oxygen uptake of the Tardigrada (Jennings, 1975).

Hypsibius (*Hypsibius*) *dujardini* (Doy. 1840)
Fig. 6

Length 115–428 μm., typically 249 μm. Cuticle smooth. Eyespots present. Bulb oval (28 μm. by 23 μm.) with two macroplacoids, the first usually with a marked constriction and slightly longer (5 μm.) than the second (4 μm.). Microplacoid absent from all but one specimen. Primary branch of claw with accessory points and longer than secondary. Eggs laid in moulted cuticle.

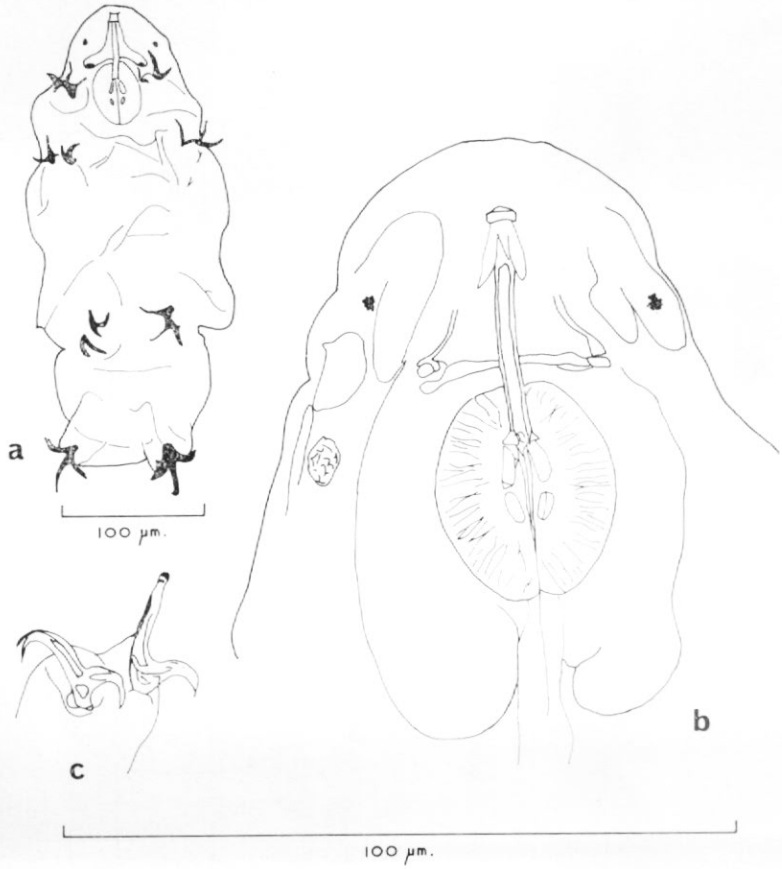

Fig. 6. *Hypsibius* (*H.*) *dujardini* (Doy.). a. General body plan; b. Detail of buccal apparatus; c. Detail of claw

An algal feeder (Baumann, 1961) which was very widespread on Signy Island and sometimes occurred in very large numbers. Found in sites A, B, C, D, E, F, G, H, 5, 8, 11, 12, 17, 18, 21, 24, 25, 26, 27, 28, 31 and 32. A cosmopolitan species.

Hypsibius (*Isohypsibius*) *asper* (J. Murr. 1906)
Fig. 7

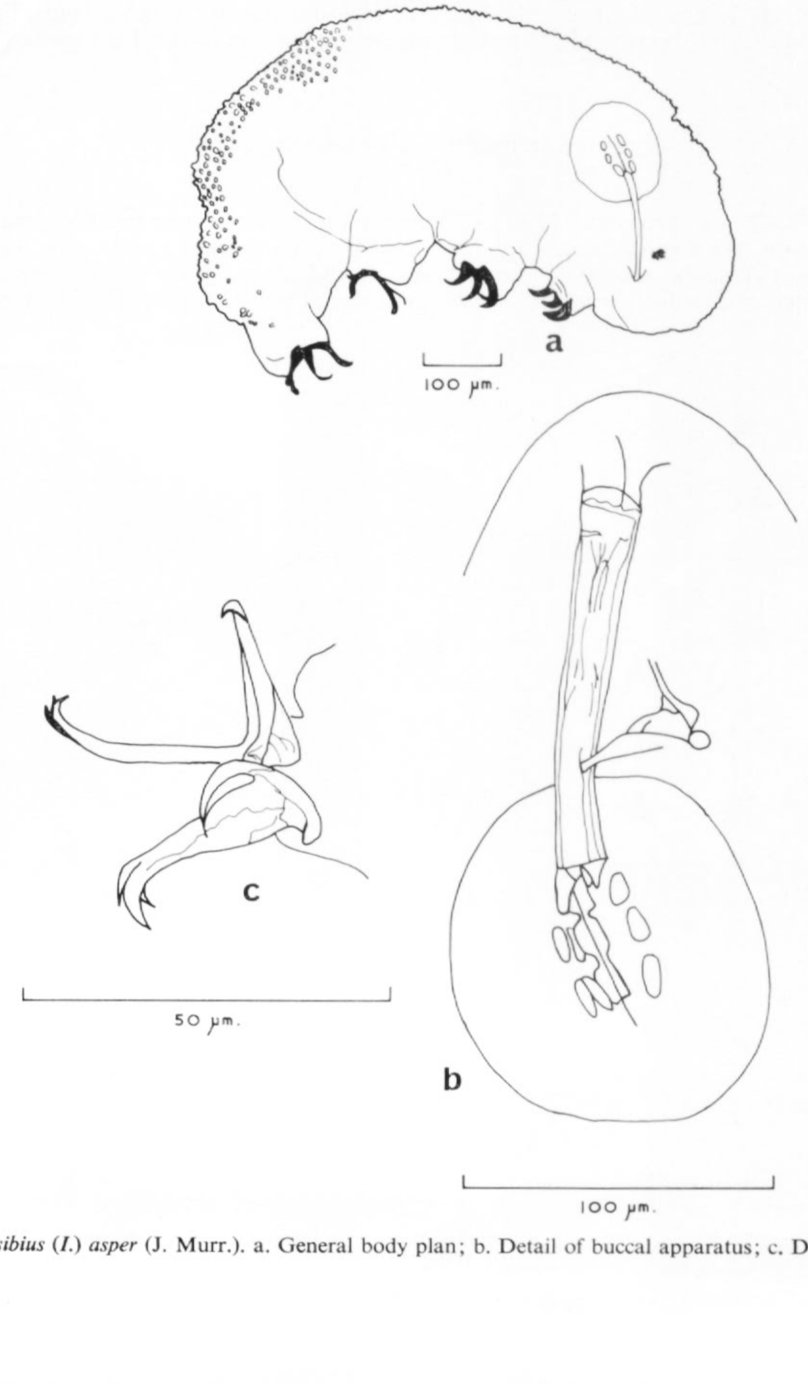

Fig. 7. *Hypsibius* (*I.*) *asper* (J. Murr.). a. General body plan; b. Detail of buccal apparatus; c. Detail of claw.

Length 141–565 μm., typically 325 μm. Cuticle dorsally covered with tubercles increasing in size from anterior to posterior. Eyespots present. Buccal aperture sub-terminal. Buccal tube 44 μm. long, 2 μm. internal diameter. Bulb almost round (45 μm. by 44 μm.), containing three granular macroplacoids. Placoid line 21 μm. long. Microplacoid absent. Claws large, primary branch 42 μm. long. Up to 17 eggs found in the moulted cuticle.

Occurring in both terrestrial and aquatic habitats, this species was recovered from sites F, 12, 21, 29, 30, 31, 33, 34 and 35. Originally described from the South Orkney Islands, it has been found at only two sites outside Antarctica, both in Europe.

Hypsibius (*Isohypsibius*) *papillifer* (J. Murr. 1905)
Fig. 8

Length 147 μm. Cuticle with nine transverse lines of small conical projections, interspersed with confused irregular granulation. Bulb with three granular macroplacoids, the third being largest; microplacoid absent.

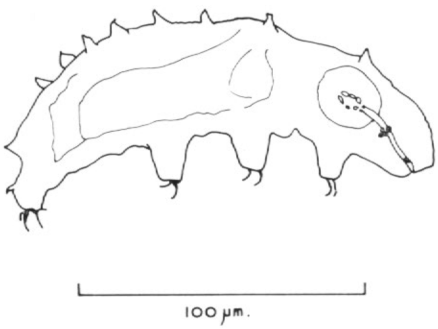

Fig. 8. *Hypsibius* (*I.*) *papillifer* (J. Murr.). General body plan.

Only a single specimen was found, from site 31. The species is cosmopolitan.

Hypsibius (*Isohypsibius*) *renaudi* Ramazzotti 1972
Fig. 9

Length 144–473 μm., typically 309 μm. Cuticle smooth. Eyespots present. Buccal aperture sub-terminal. Buccal tube 40 μm. long, 2–4 μm. wide. Bulb with two macroplacoids, the first (7 μm. long) having a medial constriction and the second (4 μm.) with or without a constriction. Principal branch of the external double claw always very long (up to 40 μm.), fine and very curved. Secondary branch, and internal double claws, robust. Accessory points on primary branches of both internal and external claw. Eggs laid in the cuticle.

This description differs from the original (Ramazzotti, 1972*b*) in the possession of accessory points on the claws.

Some animals carried up to 14 epizoic peritrichs of the genus *Epistylis* (personal communication from H. G. Smith). Previous accounts of an association between a protozoan (*Pyxidium tardigradum* Van der Land) and a tardigrade were reported by Van der Land (1964) and Iharos (1966).

On Signy Island the species was recovered from sites 3, 13, 20 and 22, being absent from all the aquatic habitats. It was originally described from Iles Kerguelen, the only other locality from which it has been recorded.

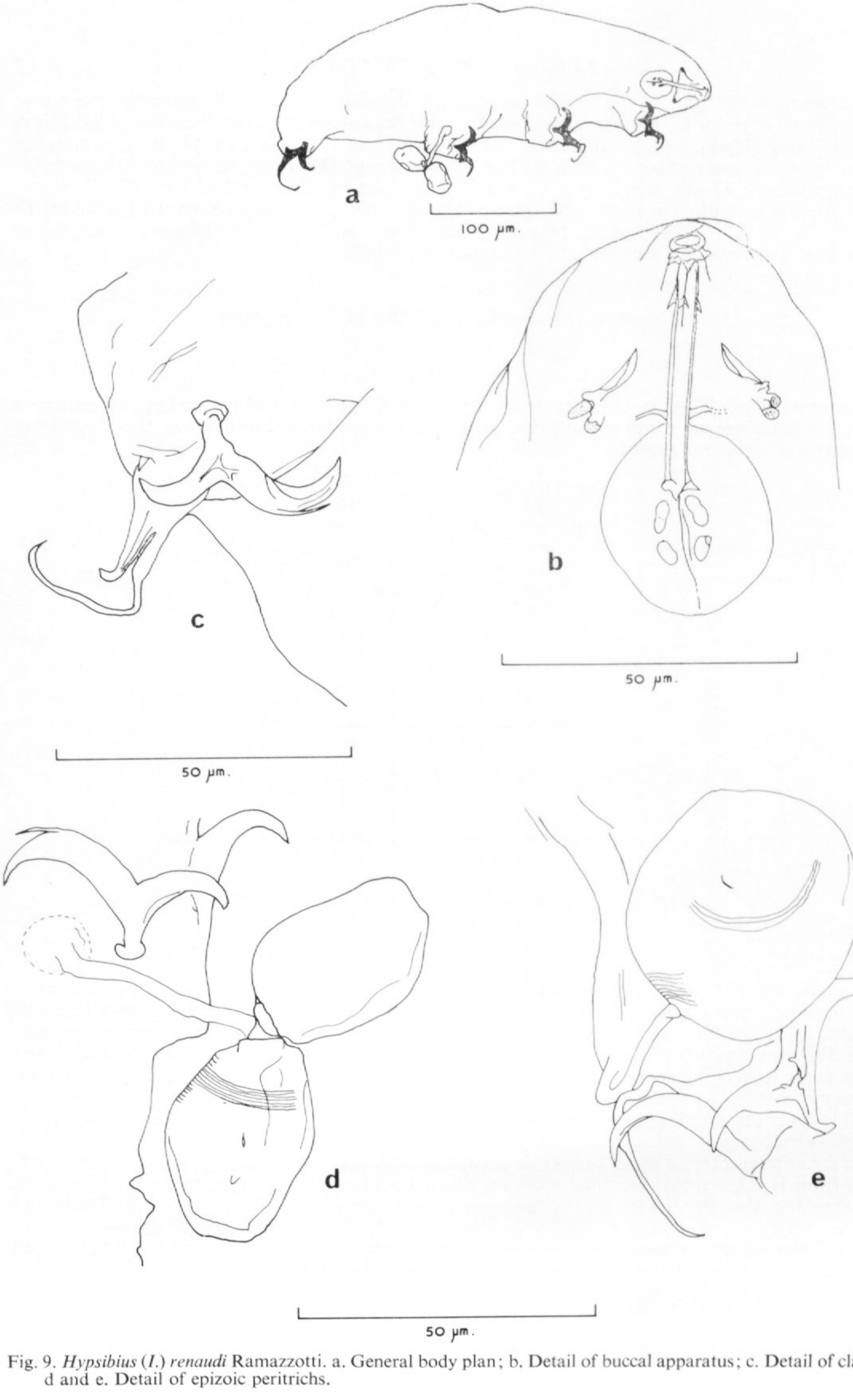

Fig. 9. *Hypsibius* (*I.*) *renaudi* Ramazzotti. a. General body plan; b. Detail of buccal apparatus; c. Detail of claw; d and e. Detail of epizoic peritrichs.

Hypsibius (*Diphascon*) *alpinus* (J. Murr. 1906)
Fig. 10a

Length 126–285 μm., typically 191 μm. Cuticle smooth. Eyespots absent. Buccal aperture sub-terminal. Buccal tube 0·5–1·5 μm. in diameter, with ring markings. Bulb an elongated oval (19 μm. by 13 μm.). Three macroplacoids, short rods increasing in length from the first to the third (4 μm.). Placoid line 14 μm. long. Microplacoids and septulum present. Eggs found in the discarded cuticle.

The taxonomic difficulties experienced in distinguishing this species from other members of the sub-genus *Diphascon* have been discussed by Petersen (1951). In the routine countings, no separation has been made between this species and *Hypsibius* (*Diaphascon*) *pinguis* Marcus, and it was also found difficult to separate these two species from *Hypsibius* (*Diphascon*) *chilenensis* (Plate), at the low magnifications used for counting (×45 and ×150). In this description the three characters used to distinguish between these three species are diameter of the buccal tube, length of the placoid line and length of the third macroplacoid. These discriminatory characters are given in Table V.

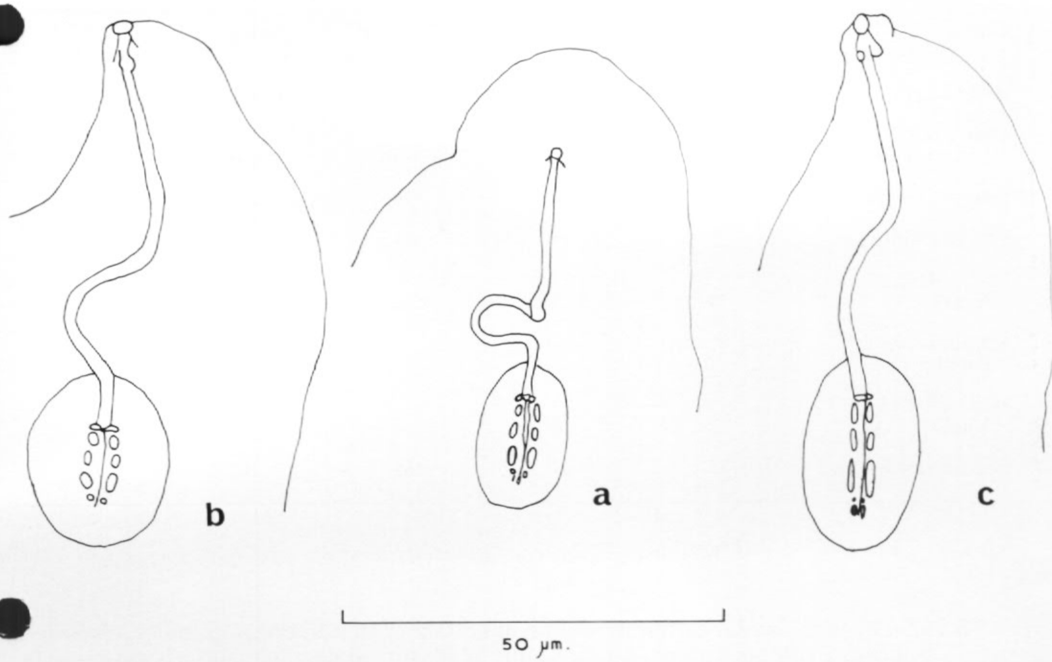

Fig. 10. Detail of buccal apparatus. a. *Hypsibius* (*D.*) *alpinus* (J. Murr.); b. *Hypsibius* (*D.*) *chilenensis* (Plate); c. *Hypsibius* (*D.*) *pinguis* Marcus.

Hypsibius (*Diphascon*) *chilenensis* (Plate 1888)
Fig. 10b

Length 160–251 μm. Cuticle smooth. Eyespots absent. Buccal aperture sub-terminal. Buccal tube 1 μm. diameter, with ring markings. Bulb almost round (22 μm. by 19 μm. for 160 μm. specimen). Three macroplacoids, granules all of about equal length (3 μm.). Placoid line 10 μm. long. Microplacoids present, septulum absent.

This species was recovered from sites G, 1, 11, 12 and 14. The species is cosmopolitan.

Hypsibius (*Diphascon*) *pinguis* Marcus 1936
Fig. 10c

Length 129–235 μm., typically 182 μm. Cuticle smooth. Eyespots absent. Buccal aperture sub-terminal. Buccal tube 1·0–2·0 μm. diameter, with ring markings. Bulb an elongated oval (29 μm. by 18 μm.). Three macroplacoids, rods increasing in length from first to third (6 μm.). Placoid line 18 μm. long. Microplacoids and septulum present. Eggs seen in the discarded cuticle.

The species group *alpinus*+*pinguis* was recovered from all sites except B, 3, 7, 13, 15, 18, 22, 26, 27, 28, 29, 31, 32 and 35.

TABLE V. CHARACTERS USED TO DISCRIMINATE BETWEEN THE MEMBERS OF THE SUB-GENUS *Diphascon* FOUND IN THIS STUDY. ALL MEASUREMENTS ARE IN μm.

	scoticus	*pinguis*	*alpinus*	*chilenensis*	*puniceus* n. sp.
Colour	None	None	None	None	Pink
Cuticle	Smooth	Smooth	Smooth	Smooth	Caudal granulation
Body length	138–488	129–235	126–285	160–251	142–176
Diameter of buccal tube	1·5–3·0	1·0–2·0	0·5–1·5	1·0	1·0
Pharynx length	50	29	19	22	11
Pharynx width	26	18	13	19	6
Macroplacoid 1 length	9	3	2	3	2
Macroplacoid 2 length	7	4	3	3	1
Macroplacoid 3 length	12	6	4	3	1
Placoid row length	35	18	14	10	10

Hypsibius (*Diphascon*) *puniceus* n. sp.
Fig. 11

Length 142–176 μm. Caudal extremity of dorsal surface with numerous granules, elsewhere the cuticle smooth. Eyespots absent. Animal pink in colour. Stylets fine and almost straight. Buccal aperture sub-terminal. Buccal tube narrow (1 μm. in diameter), with ring markings. Bulb oval, 11 μm. by 6 μm. (for 142 μm. specimen), with small apophyses and three granular macroplacoids, decreasing in size from the first to the third. Microplacoids present. Septulum absent. Placoid line 10 μm. long. Claws of the normal *Hypsibius* type, bearing accessory points on the principal branches. Eggs were not found.

No other species on Signy Island has the pink coloration of *H.* (*D.*) *puniceus* n. sp., from which its name is derived. This coloration alone separates the species from most of the sub-genus *Diphascon*. The possession of granulation at the caudal extremity confirms the separation between this and the similar species *H.* (*D.*) *chilenensis langhovdensis* Sudzuki. The small bulb and relative sizes of the macroplacoids distinguish *H.* (*D.*) *puniceus* from *H.* (*D.*) *alpinus* and *H.* (*D.*) *pinguis* (Table V).

This species was collected from sites A, F and 2 only. The holotype and paratype are held by the British Antarctic Survey and both were collected from site A in October 1972.

TABLE VI. THE DISTRIBUTION AND PERCENTAGE OCCURRENCE OF 14 SPECIES/SPECIES GROUPS OF TARDIGRADA IN 43 SAMPLES. (+ = < 1 PER CENT OCCURRENCE OR PRESENCE ONLY WHERE TOTAL RECOVERY WAS LESS THAN TEN INDIVIDUALS)

		Oreella mollis	*Echiniscus (E.) capillatus + E. meridionalis*	*Macrobiotus ambiguus*	*Macrobiotus furciger*	*Hypsibius (H.) dujardini*	*Hypsibius (I.) asper*	*Hypsibius (I.) renaudi*	*Hypsibius (I.) papillifer*	*Hypsibius (D.) alpinus + H. pinguis*	*Hypsibius (D.) chilenensis*	*Hypsibius (D.)* sp.	*Hypsibius (D.) puniceus*	*Hypsibius (D.) scoticus*	*Milnesium tardigradum*	*Total number of specimens*	*Number of species per site*
A. *Andreaea/Usnea*	Mar. 1973	1	1	[illegible]	[illegible]	54	—	—	—	42	—	—	+	1	—	4,436	7
1. *Andreaea/Usnea*	Apr. 1971	—	—	—	21	—	—	—	—	74	5	—	—	—	—	21	3
2. *Andreaea/Usnea*	Oct. 1972	—	—	—	5	—	—	—	—	91	—	—	4	—	—	80	3
3. Crustose lichens	Aug. 1972	—	—	—	—	—	—	100	—	—	—	—	—	—	—	17	1
B. *Caloplaca*	Mar. 1973	—	2	—	—	36	—	—	—	—	—	—	—	—	62	85	3
4. *Caloplaca*	Sep. 1971	—	—	—	—	—	—	—	—	100	—	—	—	—	—	25	1
5. *Polytrichum*	May 1971	—	—	—	+	+	—	—	—	+	—	—	—	—	—	8	3
6. *Chorisodontium*	Oct. 1972	—	—	—	+	—	—	—	—	+	—	—	—	—	—	5	2
C. SIRS 1	Mar. 1973	—	—	—	64	10	—	—	—	26	—	—	—	—	—	103	3
7. *Brachythecium*	Oct. 1972	—	—	—	+	—	—	—	—	—	—	—	—	—	+	5	2
8. *Brachythecium*	Feb. 1973	—	—	—	—	5	—	—	—	94	—	—	—	1	—	137	3
9. *Drepanocladus* and *Brachythecium*	Mar. 1964	—	—	—	—	—	—	—	—	+	—	+	—	—	+	9	3
H. *Drepanocladus*	Mar. 1973	—	—	—	4	23	—	—	—	66	—	—	—	7	—	2,945	4
10. *Drepanocladus*	Mar. 1971	—	—	—	+	—	—	—	—	+	—	—	—	—	—	2	2
11. *Drepanocladus*	Feb. 1973	—	+	—	6[illegible]	2	—	—	—	92	+	—	—	—	—	244	5
D. SIRS 2	Mar. 1973	—	+	—	22	2	—	—	—	75	—	—	—	+	—	3,770	5
E. *Prasiola*	Mar. 1973	—	—	—	+	98	—	—	—	1	—	—	—	+	—	22,592	4
12. *Prasiola*	Apr. 1971	7	—	—	—	7	57	—	—	7	7	—	—	7	7	14	8
13. *Prasiola* and lichen	Sep. 1971	—	—	—	—	—	—	100	—	—	—	—	—	—	—	15	1
14. *Prasiola*	Feb. 1972	—	—	—	69	—	—	—	—	23	8	—	—	—	—	13	3
15. *Prasiola*	Feb. 1972	—	+	—	+	—	—	—	—	—	—	—	—	+	—	10	3
16. *Prasiola* and *Drepanocladus*	Oct. 1972	—	—	—	9	—	—	—	—	36	—	—	—	36	19	11	4
17. *Prasiola* and lichen	Oct. 1972	—	—	—	61	2	—	—	—	2	—	—	—	—	35	128	4
18. *Prasiola*	Oct. 1972	—	—	—	+	+	—	—	—	—	—	—	—	—	—	4	2
19. *Prasiola*	Oct. 1972	—	—	—	—	—	—	—	—	+	—	—	—	—	—	5	1
20. *Prasiola*	Jan. 1973	—	—	—	21	—	—	36	—	43	—	—	—	—	—	19	3
F. *Deschampsia*	Mar. 1973	—	+	—	—	70	+	—	—	28	—	—	+	1	+	399	7
21. *Deschampsia*	Apr. 1971	—	—	—	—	+	+	—	—	+	—	—	—	—	—	4	3
G. Wallow material	Mar. 1973	—	—	—	1	93	—	—	—	5	+	—	—	+	—	16,606	5
22. Organic material	Feb. 1972	—	—	—	—	—	—	100	—	—	—	—	—	—	—	16	1
23. Organic material	Apr. 1971	—	—	—	2	—	—	—	—	4	—	—	—	94	—	64	3
24. Organic material	Feb. 1973	—	8	—	—	38	—	—	—	54	—	—	—	—	—	13	3
25. Pool	Mar. 1971	—	—	—	—	36	—	—	—	64	—	—	—	—	—	16	2
26. Pool	Feb. 1972	—	—	—	—	+	—	—	—	—	—	—	—	—	—	6	1
27. Pool 2B	Feb. 1972	—	—	—	—	100	—	—	—	—	—	—	—	—	—	12	1
28. Pool 4	Feb. 1972	—	—	—	—	100	—	—	—	—	—	—	—	—	—	17	1
29. Lake	Apr. 1971	—	—	—	—	—	+	—	—	—	—	—	—	—	—	4	1
30. Lake	May 1971	—	—	—	—	—	+	—	—	+	—	—	—	+	—	4	3
31. Lake 1	Jan. 1964	—	—	—	—	+	+	—	+	—	—	—	—	—	—	8	3
32. Lake 2	Feb. 1964	—	—	+	—	+	—	—	—	—	—	—	—	—	—	2	2
33. Lake 2	Mar. 1971	—	—	+	—	—	+	—	—	+	—	—	—	—	—	5	3
34. Lake 2, bottom	Jan. 1973	—	—	—	5	—	7	—	—	88	—	—	—	—	—	132	3
35. Lake 3	Sep. 1964	—	—	+	—	—	+	—	—	—	—	—	—	—	—	2	2
Species occurrence in:																	
43 samples		2	7	3	21	22	9	4	1	29	5	1	3	12	7		
32 terrestrial habitats		2	7	0	20	16	3	4	0	25	5	1	3	11	7		
11 aquatic habitats		0	0	3	1	6	6	0	1	4	0	0	0	1	0		

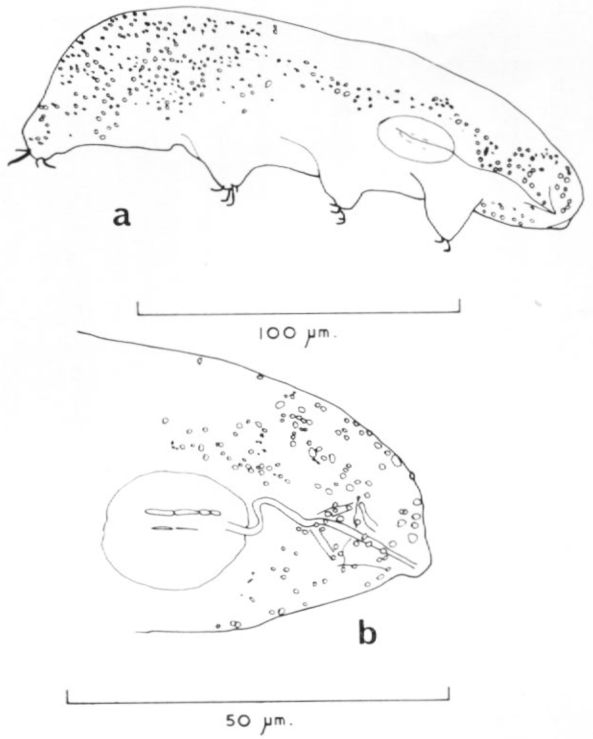

Fig. 13. *Hypsibius* (*D.*) sp. a. General body plan; b. Detail of buccal apparatus.

Family Milnesiidae Ramazzotti 1962

Milnesium tardigradum Doy. 1840
Fig. 14

Length 547–947 μm. Cuticle smooth. Eyespots present. Animal orange-red in colour. Buccal aperture large and terminal, surrounded by fleshy papillae. Muscular pharynx without macroplacoids. Claws distinctive, with two very long branches and two short three-hooked members on each leg. The species is carnivorous and several complete ramate trophi from delloid rotifers were found in the gut of several specimens (Fig. 14d).

This large, easily identified terrestrial species was found at sites B, F, 7, 9, 12, 16 and 17. The species is cosmopolitan.

Results and Discussion

The 43 sites investigated revealed five genera and 16 species of Tardigrada. This is one genus more than has previously been reported from the Antarctic (Sudzuki, 1964), the new record being *Oreella*. Only five species were described in full by Murray (1906) from the South Orkney Islands, and all of these have been found in the present study. Two of Murray's new species have subsequently been re-named. The species common to both studies were *E.* (*E.*) *meridionalis*, *M. asper*, *M. furciger*, *H.* (*D.*) *alpinus* and *H.* (*D.*) *chilenensis*. None of the additional 11 species which have been recognized in this study corresponds to any of Murray's seven incompletely described species.

The distribution of all 14 species/species groups over the 43 sites investigated is given in Table VI. From all sites where more than ten Tardigrada were recovered, a figure for the

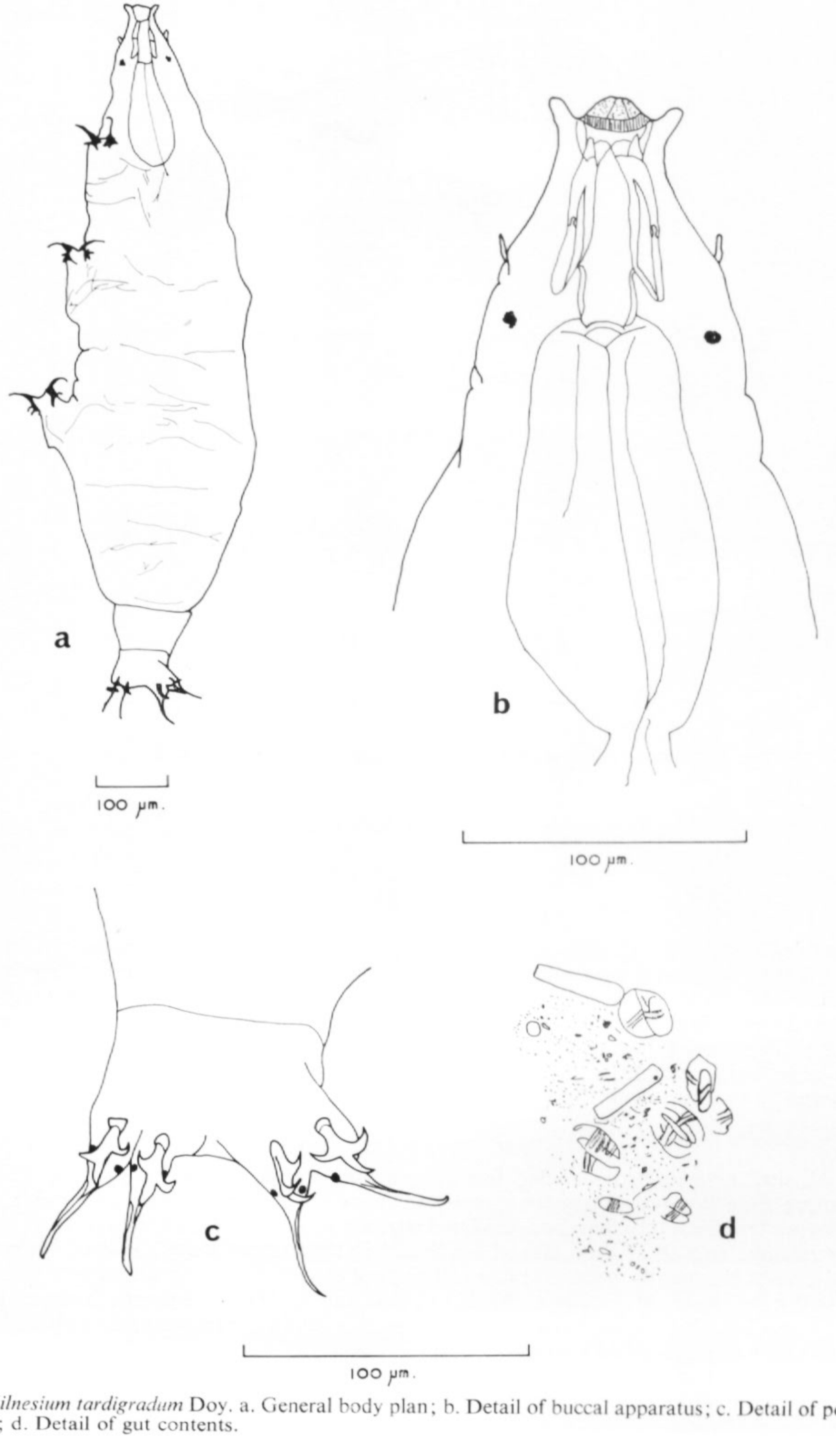

Fig. 14. *Milnesium tardigradum* Doy. a. General body plan; b. Detail of buccal apparatus; c. Detail of posterior claws; d. Detail of gut contents.

per cent occurrence of each species has been given. Clearly, greater confidence can be held in these percentages where the number of specimens identified exceeds 100 than in those where only a few specimens were recovered. In terms of their distribution, three species/species groups stand out as being very widespread; these are *M. furciger*, *H.* (*H.*) *dujardini* and *H.* (*D.*) *alpinus* + *H. pinguis*. All of these occur in both the terrestrial and aquatic habitats. The habitat preferences of each tardigrade species become more apparent when the data are grouped according to habitat type (e.g. vegetation sub-formation, organic material, pools and lakes) in Table VII. There is some indication that organic waste from seals and birds increases the species diversity and the density of Tardigrada. The foliose alga *Prasiola crispa* has the most diverse fauna, with ten of the 14 species/species groups represented. Two components are present in high proportions in all habitat groups of Table VII. These are *H.* (*H.*) *dujardini* and *H.* (*D.*) *alpinus* + *H. pinguis* type. The next most abundant species is *M. furciger* which occurs in six of the nine habitat types (*E.* (*E.*) *capillatus* + *E. meridionalis* and *H.* (*D.*) *scoticus* also occur in six types but not with as high proportions as *M. furciger*). These four species alone account for over 90 per cent of the tardigrade fauna in six of the habitat types in Table VII, and for 95·1 per cent of the total biomass. The three habitat types in which the proportion falls below 90 per cent occurrences are all affected by vertebrates. In these habitat types, other components become proportionally more important than elsewhere and *H.* (*I.*) *renaudi*, for example, is completely absent from all other sites. *H.* (*D.*) *scoticus*, although fairly widespread, shows particular preference for the rich organic soils of elephant-seal wallows, alluvial deposits and under *Prasiola*. *Miln. tardigradum* reaches a high proportion in only two of the habitat types, and here enrichment is probably not the only causal factor. Whereas most habitats on Signy Island are to some extent sheltered from the most severe conditions by snow cover, both crustose lichens and *Prasiola*, although usually benefitting by enrichment from some source, colonize extremely exposed positions on scree, cliff faces and bluffs. The index of humidity for *Caloplaca* (a crustose lichen) is 2·32 and for *Prasiola* it is 2·01. Both these are considerably less than the mean value (5·90) from all other sites (Table IV). Mihelčič (1954) has placed *Miln. tardigradum* in a division which he termed the Eurytope, that is, a habitat subject to a wide range of ambient humidities. The distribution found in this study (Table VII) would support this classification. Of the remaining species, only those of the genus *Echiniscus* were widespread but never abundant. They were never observed in an aquatic environment. It would be difficult to comment on the distribution of *O. mollis*, *M. ambiguus*, *H.* (*I.*) *papillifer*, *H.* (*I.*) *asper*, *H.* (*D.*) *chilenensis*, *H.* (*D.*) *puniceus* and *H.* (*D.*) sp. as their distribution and abundance are all limited. The distribution and abundance of ten species/species groups in the eight sites used for quantitative examinations are shown in Table VIII. In the surface 3 cm. total numbers varied from $0 \cdot 011 \times 10^6$/m.^{2} in the *Polytrichum–Chorisodontium* moss turf (C) to $14 \cdot 130 \times 10^6$/m.^{2} in a mat of *P. crispa* (E) situated near a large elephant-seal wallow. There is no apparent correlation between total tardigrade density and either pH or moisture content (Table IV). Thus the presence of vertebrate enrichment would appear to be the most important single factor governing tardigrade population densities between sites. The very low population density in the *Polytrichum–Chorisodontium* moss turf has been noted at other localities (Ramazzotti, 1958) and is probably attributable to either the absence of suitable food organisms in this moss type or the mechanical difficulties of piercing the thick cell walls with tardigrade stylets. While interpreting the data in Table VIII, it must be remembered that the sites showing the highest densities are those which are very restricted in their cover. Tilbrook (1970) has estimated that less than 5 per cent of the snow-free surface of Signy Island consists of "ornithogenic" soils, and this point has been further discussed by Collins and others (1975). No seasonal trend was apparent on the three sites sampled in October and March.

Using the mean tardigrade weight (from Table II) and the number of each species in Table VIII, an estimate of biomass for each species on the eight sites used in the quantitative study has been made (Table IX). The lowest total weight of tardigrades is found on the *Polytrichum–Chorisodontium* moss turf (C) at 26·1 mg./m.^{2}, while all those sites affected by vertebrates (B, E, G and H) have total tardigrade weights in excess of 1 g./m.^{2} (1·2–19·8 g./m.^{2}). The remainder of the sites (A, D and F) have total tardigrade weights of 171–636 mg./m.^{2}. A comparison (Table X) of the densities and total biomass found in this study with samples obtained in a similar manner elsewhere (Hallas and Yeates, 1972; Haka and others, 1974)

TABLE VII. THE DISTRIBUTION AND MEAN PERCENTAGE OCCURRENCE OF 14 SPECIES/SPECIES GROUPS OF TARDIGRADA IN NINE BROAD HABITAT TYPES (FROM TABLE VI)

	Crustose lichen	*Organic material*	*Prasiola*	*Lakes*	*Moss cushion*	*Moss carpet*	*Des-champsia*	*Pools*	*Moss turf*
Number of sites giving per cent abundance	3	4	7	1	3	4	1	3	1
Oreella mollis	—	—	1·0	—	0·3	—	—	—	—
Echiniscus (*E.*) *capillatus*+*E. meridionalis*	0·6	2·0	+	—	0·3	+	+	—	—
Macrobiotus ambiguus	—	—	—	+	—	—	—	—	—
Macrobiotus furciger	—	0·7	22·9	5·0	8·6	8·0	—	—	64·0
Hypsibius (*H.*) *dujardini*	12·0	32·7	15·3	+	18·0	8·0	70·0	78·6	10·0
Hypsibius (*I.*) *asper*	—	—	8·2	7·0	—	—	+	—	—
Hypsibius (*I.*) *renaudi*	33·3	25·0	19·5	—	—	—	—	—	—
Hypsibius (*I.*) *papillifer*	—	—	—	+	—	—	—	—	—
Hypsibius (*D.*) *alpinus*+*H. pinguis*	33·3	15·7	16·0	88·0	69·0	81·7	28·0	21·3	26·0
Hypsibius (*D.*) *chilenensis*	—	+	2·2	—	1·6	+	—	—	—
Hypsibius (*D.*) *puniceus*	—	—	—	—	1·3	—	+	—	—
Hypsibius (*D.*) *scoticus*	—	23·5	6·2	+	0·3	2·0	1·0	—	—
Hypsibius (*D.*) sp.	—	—	—	—	—	+	—	—	—
Milnesium tardigradum	20·6	—	8·7	—	—	+	+	—	—
Number of species	5	7	10	8	8	8	7	2	3
Accumulate percentage of: *Macrobiotus furciger*, *Hypsibius alpinus* +*H. pinguis* and *Hypsibius dujardini*	45·3	49·1	54·2	93·0	95·6	97·7	98·0	99·9	100·0

Table IX. Estimate of biomass per m.[2] of tardigrade species/species groups in eight sites on Signy Island (in mg.)

	Date	*Oreella mollis*	*Echiniscus (E.) capillatus + E. meridionalis*	*Macrobiotus furciger*	*Hypsibius (H.) dujardini*	*Hypsibius (I.) asper*	*Hypsibius (D.) alpinus + H. pinguis*	*Hypsibius (D.) chilenensis*	*Hypsibius (D.) puniceus*	*Hypsibius (D.) scoticus*	*Milnesium tardigradum*	*Total Tardigrada*
A. *Andreaea–Usnea*	Oct. 1972	—	1·5	18·4	12·0	—	132·9	—	1·5	41·7	—	208·0
Andreaea–Usnea	Mar. 1973	0·2	4·1	0·5	416·1	—	213·9	—	0·8	0·3	—	635·9
B. Crustose Lichen	Mar. 1973	—	1·0	—	35·5	—	—	—	—	—	1,155·4	1,191·9
C. Moss turf	Mar. 1973	—	—	22·5	1·2	—	2·4	—	—	—	—	26·1
D. Moss carpet	Oct. 1972	—	0·9	248·1	19·2	—	340·9	—	—	—	—	609·1
Moss carpet	Mar. 1973	—	0·3	373·6	0·1	—	186·9	—	—	—	—	560·9
E. *Prasiola*	Mar. 1973	—	—	22·4	19,621·1	8·5	111·9	—	—	7·5	—	19,771·4
F. *Deschampsia*	Oct. 1972	—	1·9	6·4	28·1	4·3	90·7	—	0·4	39·2	—	171·0
Deschampsia	Mar. 1973	—	1·1	—	114·3	1·7	34·5	—	0·4	3·7	23·7	179·4
G. Wallow material	Mar. 1973	—	—	191·6	6,476·5	81·1	264·1	0·5	—	0·9	—	7,014·7
H. *Drepanocladus*	Mar. 1973	—	—	155·8	281·4	—	617·6	—	—	159·8	—	1,214·6
Per cent of total biomass on all sites		≪0·1	≪0·1	3·3	85·5	0·3	6·3	≪0·1	≪0·1	0·8	3·7	

Table VIII. The distribution and mean density per $m.^2$ of tardigrade species/species groups in eight sites on Signy Island. Confidence limits at the 95 per cent level are shown in italics

	Date	*Oreella mollis*	*Echiniscus (E.) capillatus + E. meridionalis*	*Macrobiotus furciger*	*Hypsibius (H.) dujardini*	*Hypsibius (I.) asper*	*Hypsibius (D.) alpinus + H. pinguis*	*Hypsibius (D.) chilenensis*	*Hypsibius (D.) puniceus*	*Hypsibius (D.) scoticus*	*Milnesium tardigradum*	*Total Tardigrada*
A. *Andreaea–Usnea*	Oct. 1972	—	2,000 *1,173*	4,286 *1,173*	8,571 *10,088*	—	123,429 *97,892*	—	1,286 *454*	16,571 *20,249*	—	153,429 *69,897*
Andreaea–Usnea	Mar. 1973	4,450 *2,205*	5,600 *2,558*	114 *239*	297,257 *103,953*	—	198,743 *53,535*	—	686 *701*	114 *239*	—	506,971 *110,269*
B. Crustose lichen	Mar. 1973	—	1,371 *3,813*	—	25,371 *43,336*	—	—	—	—	—	43,429 *69,491*	70,171 *69,663*
C. Moss turf	Mar. 1973	—	—	5,236 *5,133*	860 *1,805*	—	2,188 *1,418*	—	—	—	—	11,097 *7,059*
D. Moss carpet	Oct. 1972	—	1,262 *1,548*	57,686 *32,534*	13,735 *19,293*	—	316,639 *137,150*	—	—	—	—	394,370 *158,064*
Moss carpet	Mar. 1973	—	371 *382*	86,862 *32,177*	74 *155*	—	173,651 *59,677*	—	—	—	—	272,763 *75,583*
E. *Prasiola*	Mar. 1973	—	—	5,197 *4,655*	14,017,068 *3,307,459*	1,485 *3,103*	103,938 *207,504*	—	—	2,970 *4,828*	—	14,130,657 *3,242,235*
F. *Deschampsia*	Oct. 1972	—	2,598 *2,261*	1,485 *1,927*	20,045 *38,044*	742 *2,361*	84,264 *14,728*	—	371 *1,181*	15,578 *50,711*	—	115,074 *48,785*
Deschampsia	Mar. 1973	—	1,485 *1,527*	—	81,666 *53,047*	297 *621*	32,072 *10,440*	—	297 *621*	1,485 *1,527*	891 *1,071*	118,192 *60,484*
G. Wallow material	Mar. 1973	—	—	44,545 *46,424*	4,626,722 *2,566,832*	14,106 *17,720*	245,368 *214,605*	742 *2,361*	—	371 *1,181*	—	4,931,483 *2,607,175*
H. *Drepanocladus*	Mar. 1973	—	—	36,230 *67,935*	201,046 *94,832*	—	573,737 *355,365*	—	—	63,551 *48,093*	—	874,563 *392,279*

TABLE X. COMPARISON OF MEAN TARDIGRADE DENSITY AND BIOMASS PER m.^{2} FOR THIS AND OTHER STUDIES

Locality	*Substrate*	*Tardigrada*/m.^{2}	mg./m.^{2}	*Authority*
Denmark	Forest, *Fagus sylvaticus*	4,060	5·4	Hallas and Yeates (1972)
	Forest, *Pinus nigra*	12,592	—	
	Grass	624	—	
Finland	Lake Pääjärvi, stony-littoral	—	0·1	Haka and others (1974)
Signy Island	Moss turf, *Polytrichum–Chorisodontium*	11,097	26·1	This paper
	Grass, *Deschampsia antarctica*	118,192	179·4	
	Alga, *Prasiola crispa*	14,130,657	19,771·4	

indicates that the Signy Island habitats are relatively rich in Tardigrada. Unfortunately no comparable data are available for the occurrence of tardigrades in mosses.

The distribution and abundance of four broad taxonomic groupings of Rotifera in eight sites are given in Table XI. Little pattern emerges from these data, although it is noteworthy

TABLE XI. THE DISTRIBUTION AND MEAN DENSITY PER m.^{2} OF ROTIFER GROUPS IN EIGHT SITES ON SIGNY ISLAND. CONFIDENCE LIMITS AT THE 95 PER CENT LEVEL ARE SHOWN IN ITALICS

Site	*Date*	*Adineta*	*Bdelloidea (other than Adineta)*	*Monogononta*	*Unidentified*	*Total Rotifera*
A. *Andreaea–Usnea*	Oct. 1972	6,720 *7,489*	8,960 *5,948*	13,840 *6,223*	4,320 *4,709*	33,760 *12,327*
Andreaea–Usnea	Mar. 1973	10,320 *4,282*	61,040 *21,907*	2,800 *1,830*	32,320 *8,548*	106,480 *27,795*
B. Crustose lichen	Mar. 1973	1,920 *4,312*	169,040 *308,142*	—	195,520 *437,979*	366,480 *749,633*
C. Moss turf	Mar. 1973	11,433 *20,575*	69,037 *33,667*	—	28,391 *20,174*	108,861 *54,196*
D. Moss carpet	Oct. 1972	43,342 *22,733*	51,709 *44,388*	1,611 *1,184*	11,329 *10,601*	107,992 *69,889*
Moss carpet	Mar. 1973	14,291 *18,368*	6,756 *9,452*	—	7,068 *7,531*	28,115 *25,961*
E. *Prasiola*	Mar. 1973	55,815 *15,503*	677,571 *335,997*	48,747 *27,127*	205,589 *69,399*	931,388 *403,022*
F. *Deschampsia*	Oct. 1972	7,276 *8,794*	424,690 *333,316*	11,641 *4,947*	57, 789 *58,716*	497,239 *352,920*
Deschampsia	Mar. 1973	22,659 *8,904*	299,549 *100,509*	79,201 *61,090*	83,566 *45,987*	484,974 *159,480*
G. Wallow material	Mar. 1973	119,113 *153,006*	136,574 *95,767*	6,652 *10,795*	43,030 *42,546*	305,370 *256,699*
H. *Drepanocladus*	Mar. 1973	129,507 *36,153*	261,924 *116,376*	10,186 *6,505*	218,685 *124,896*	618,223 *205,871*

that the two highest population densities were recorded for sites which are known to be directly influenced by vertebrates, *Prasiola* and *Drepanocladus* (E and H). However, this group also attains moderately high densities ($0\cdot500 \times 10^6$/m.^{2}) in the *Deschampsia* site (F). Nematoda were found to reach their highest densities on Signy Island in soils under vascular plants (Spaull, 1973) with $7\cdot470 \times 10^6$/m.^{2} from a *Deschampsia* site. In a penguin rookery the population density was estimated at $4\cdot040 \times 10^6$/m.^{2}, much higher than in most of the moss communities, and in this respect similar to the distribution of the rotiferan populations in this study. Smith (1973), however, did not report a similar pattern for the Protozoa of Signy Island. No regular seasonal variation is exhibited by the Rotifera of sites A, D and F at the two samplings at the beginning and close of a single summer season. A larger sample size may have shown a seasonal effect for the Monogononta, as these were found to increase during the summer months and decline in the early winter at SIRS 2 (unpublished data of the author).

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